

Canada-B.C.

Conservation and Renewable Energy Demonstrations

B.C. 34



Energy, Mines and
Resources Canada
Conservation and
Renewable Energy Branch

Energie, Mines et
Ressources Canada
Bureau de la conservation
et des énergies renouvelable



Province of
British Columbia

Ministry of
Energy, Mines and
Petroleum Resources
CONSERVATION AND
TECHNOLOGY DIVISION

Energy Aspects Pertaining to the
50 KV Electrification of the
British Columbia Railway
Tumbler Ridge Branch Line

by

British Columbia Railway

for

B.C. Ministry of Energy, Mines and Petroleum Resources
and
Energy, Mines and Resources Canada
under the
Canada/B.C. Conservation and Renewable
Energy Demonstration Agreement

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CANADA/BRITISH COLUMBIA CONSERVATION
AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the government of British Columbia and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement is dedicated to the development and demonstration of conservation and renewable technologies.

The objectives of CREDA are:

- o To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- o To develop broad public awareness of the potential of renewable energy and conservation technology.
- o To provide opportunities for the commercial application of the technologies within B.C.
- o To create employment in new or existing energy-related industries.

50 KV ELECTRIFICATION OF THE BRITISH COLUMBIA RAILWAY

TUMBLER RIDGE BRANCH LINE

EXECUTIVE SUMMARY

Introduction

The British Columbia Railway first studied electrification of its rail system in 1968. At that time a study was undertaken to determine if it was economically feasible to electrify the existing railway that ran from North Vancouver to Prince George, British Columbia, a distance of 745 km. It was concluded that world oil prices were such that the relative price of diesel fuel would need to double in order to make electrification an economic proposition even with the low cost of capital at that time.

In 1975/76, the B.C. Railway began design studies on rail access to the North East Coal block to transport coal to Prince Rupert, B.C. Electrification was touched on as an alternative to tunnel ventilation in the proposed tunnels. However, with the information available at that time, the additional rock excavation required made the project appear not feasible.

In 1981, Electrification became an issue considered worthy of further study by the Transportation Development Centre of Transport Canada when the Railway Association of Canada publicized the possible use of electrification to overcome the speed limitations of diesel locomotives pulling high tonnage trains up on heavy grades.

The required electrical clearances for tunnels were then re-evaluated and the T.D.C. proposed a study to review the question of electrifying the Tumbler Ridge Branch Line.

In early April of 1982, B.C. Railway examined a proposal prepared by Canadian Pacific Consulting Services. By reviewing the proposed operating costs, capital savings and assistance available from the Transportation Development Centre and the Federal/Provincial Conservation and Renewable Energy program, it became clear that a unique opportunity had presented itself for B.C. Railway to come to the forefront in the use of 50 Kv electrified railroad technology.

The System

The catenary system runs the entire length of the Tumbler Ridge Branch Line and includes the load-out loops at the mine sites. The length of catenary is approximately 150 kilometers. By using a 50 kV catenary voltage, only one substation is required. The 230/50 kV substation is built at km 112 providing direct connection to B.C. Hydro and to allow for expansion of the rail line eastward as more of the coal fields are developed. The substation and catenary systems were substantially built in 1983 with completion scheduled for 1984.

Energy Conservation

The energy calculations presented in this report are based on computer simulations of the trains running on the Tumbler Ridge Branch Line. Various combinations of diesel power were simulated to arrive at the most economical operating unit. When this is compared to the energy consumption of an all electric locomotive combination, it is predicted that the electric locomotives will be 2.7 times more energy efficient than the diesel powered locomotives. Tests to be conducted during 1984 on the actual consumption of the electric locomotives will be presented as an addendum to this report when they are complete.

Demonstration Aspects

The use of electrification on the Tumbler Ridge Branch Line has shown the feasibility and economics of using 50 kV catenary wherever heavy tonnage, long grades, and/or high speeds are encountered or where the power grid is spaced far enough apart to necessitate the construction of additional power lines to feed the extra substations that are required for lower voltage systems.

Information Gained From This Project

The construction and energy conservation information gained from this project is to be made available through the Railway Association of Canada.

INTRODUCTION

There are two general types of electrical energy available for use by consumers: that derived from non-renewable sources; ie. coal, natural gas and oil, and that derived from renewable sources; i.e. hydro-electric power plants. The latter is the situation that occurs in British Columbia where hydro-electric power predominates.

The construction of the new Tumbler Ridge Branch Line by the British Columbia Railway, to be used to transport coal destined for the Japanese market, presented an opportunity to use electric powered locomotives rather than conventional diesel powered locomotives. The Tumbler Ridge branch line derived its name from the new townsite of Tumbler Ridge and a local geological formation which is called the Tumbler Ridge. The townsite was built to service the two new mines that are producing the export coal.

Energy reasons alone were not enough for the British Columbia Railway to justify the electrification of the branch line with presently contracted coal shipments; tunnel ventilation costs with a diesel system as well as speed limitations also played a major part. Nevertheless, the governments of Canada and British Columbia, through the Conservation and Renewable Energy Demonstration Agreement (CREDA) concluded that there was sufficient energy savings and the possible replication of electrified railroads of this type in Canada to grant 5 million dollars towards the construction of this project. The new line is now electrified and transporting coal from the Teck and Quintette Corporations' mines to the Far Eastern markets.

BRITISH COLUMBIA RAILWAY COMPANY

The British Columbia Railway Company (B.C. Rail) is wholly-owned by the Province of British Columbia. B.C. Rail is Canada's third largest railway with a 1600 km route from Vancouver to Fort Nelson and a branch line extending into the northwest region of British Columbia. B.C. Rail operates a rail freight service principally engaged in transporting British Columbia's natural resources from the central interior and northern parts of the Province to world markets.

B.C. Rail has an asset base of \$727 million and total annual revenues of approximately \$150 million.

The economic significance of the Company can be gauged from the fact that at present over 20 per cent of net rail freight tons loaded in British Columbia originates on the B.C. Rail line. The Railway services approximately 800 carload shippers in the province.

As part of British Columbia's north east coal development, B.C. Rail has just completed the construction of the 130 km Tumbler Ridge Branch Line. The branch line will provide the rail link to existing transportation services for the unit train movement of 8.5 million tonnes of coal annually to Japan.

DEVELOPMENT OF THE TUMBLER RIDGE BRANCH LINE

Project Outline

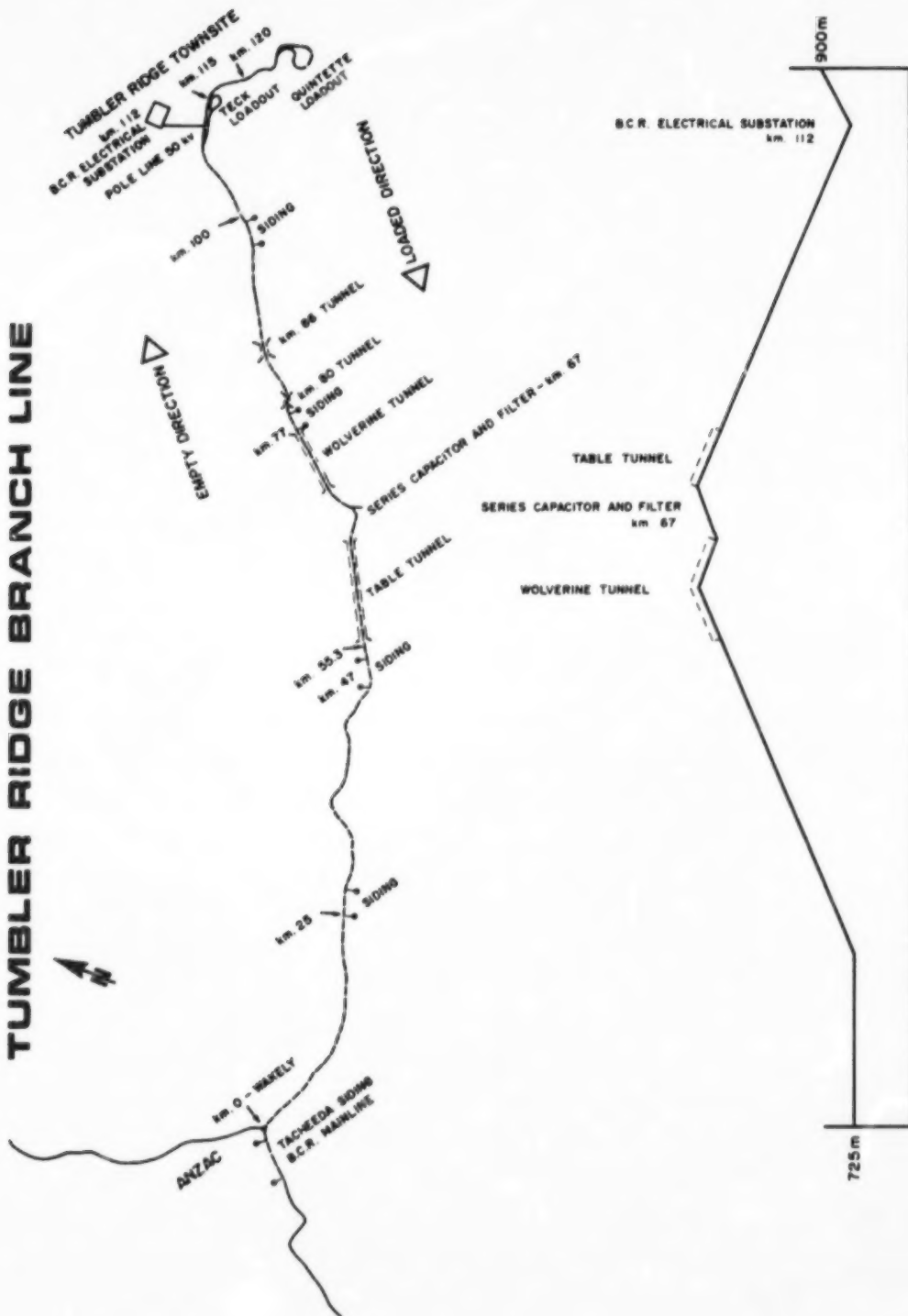
In 1976, the British Columbia Government funded a study to conduct preliminary engineering to access the Northeast Coal Block by rail. The British Columbia Railway was requested to carry out the rail feasibility study.

Two main routes were studied, one originating at Chetwynd and running in a southeasterly direction and the other originating at Anzac and running in an east-northeast direction. Both Chetwynd and Anzac are located on the B.C. Railway mainline, north of Prince George. Construction costs were determined using mapping developed to a scale of 1:5000. These costs plus operating and maintenance costs over a given duration were placed into a computer model to determine the most desirable route based on the costs developed and operating parameters.

The result of the study was that a route studied by C.N. Rail (Monkman I) was most desirable, with the B.C. Railway route, Anzac-Tumbler Ridge, being a very close second. Monkman I followed the McGregor River Valley and was in conflict with B.C. Hydro plan to divert the McGregor River and flood the valley; the Provincial Government chose the Anzac route (Fig. 1) as it wished to retain the McGregor River diversion option.

In 1977 B.C. Railway was requested to study the Anzac route in greater detail to obtain a more accurate and current estimate of construction costs. Mapping was developed to a scale of 1:2000 using photography with good vertical and horizontal ground control. Based on the new mapping data, terrain analysis and limited field information, an estimate of costs was developed. The branch line, 105 km in length, was estimated to cost \$189 million including three tunnels, each being approximately 5 km in length. This portion of the study was completed in 1978. In 1980, this study was updated to include the extension of

TUMBLER RIDGE BRANCH LINE



the branch line from 105 km to 130 km. The resultant costs were estimated to be \$310 million in 1980 dollars which included \$30 million for the extension of the branch line.

With negotiations in mid-1980 progressing favourably, the provincial government approved the conduct of detailed investigations and designs of the proposed major tunnels, including cost estimates, followed by approval to proceed with the construction of the access roads and preparation of documents to construct the first 30 kilometres of the grade.

Project approval was received in December 1980, which was followed by mobilization of engineering forces to conclude the design and supervise the construction of grade, bridges, tunnels and track. A budget in April 1981 dollars of \$374 million was developed, which finally was adjusted to an "in-place" budget of \$455 million.

Design activity commenced immediately involving B.C. Railway personnel and consulting services covering all aspects of the branch line. Grade design generally commenced from km 0 and sequentially progressed to km 130. Construction progressed in a similar fashion.

Design of the two major tunnels (Table and Wolverine) commenced with the detailed exploration program launched in late 1980 and was concluded in April 1981.

Final Design and Construction

In mid-July 1980, and upon recommendation by the B.C. Railway, the government of British Columbia decided to commit funds to carry out essential engineering designs and development of contract documents in order to keep the project on the critical path and meet the completion date of December 1, 1983.

The times that were considered to be critical were: investigations and design of the tunnels, construction of all access roads along the Table, Sukunka and Wolverine Valleys, soil investigations and design of the grade from km 0 to km 30.

By September 1980, consultants were engaged to carry out the necessary field investigations and final designs for the tunnels which would be used for preparation of contract documents and cost estimates. The field drilling and mapping programs were concluded in December 1980. Designs, contract-type cost estimates and final reports were concluded in April 1981.

During tunnel field investigations, it became apparent that the depth of overburden at the east portal of Tunnel No. 1 would be substantial (greater than 50 metres). It was decided, therefore, to combine Tunnels No. 1 and No. 2 into one long tunnel, approximately 9 km in length. This tunnel would connect the Table and Sukunka Valleys, and would be known as the "Table Tunnel". All other portals were confirmed, generally in the same locations as recommended in the 1977-1978 study (Phase II). It was also decided to refer to Tunnel No. 3 as the "Wolverine Tunnel".

Field investigation and surveys for the first 30 km of grade commenced in the fall of 1980 and were concluded in the spring of 1981 which included detailed design and preparation of contract documents.

With respect to the access roads, contract documents were prepared in December 1980, using all available data, and only field reconnaissance surveys. Forest Service standards were adopted in the design of the access roads. Contracts were awarded in January 1981 to construct 25 km of access road to the Table River Valley and 27 km in the Sukunka River Valley which would provide access to the east and west portals of the Table Tunnel and west portal of the Wolverine Tunnel. These access roads would be extensions of existing Forestry roads. Construction also included the building of a number of bridges.

Completion of access road construction was scheduled for August 15, 1981. The Wolverine access road, approximately 20 km in length, was less difficult, and preparation of contract documents and construction was scheduled for mid-1981.

Agreement in principle was reached in mid-December 1980 between the government, coal producers, and Japanese interests. With this agreement, the B.C. Railway Engineering Department was requested to form a Project Management Team (task force) and proceed with all phases of design, contract document preparation, and construction. The Project Management team was formed utilizing existing B.C. Railway engineering staff and supplemented by consulting services and new employees.

With the data developed in previous studies and additional information obtained such as geotechnical investigations and design for the first 30 km of the grade, tender prices to construct the Table and Sukunka access roads, tunnel investigations, design and cost estimates, a budget was developed in April 1981 dollars and projected to a final cost of 455 million dollars in December 1983.

Electrification

In 1968 a theoretical study was performed by B.C. Railway (then known as the Pacific Great Eastern Railway) covering existing railway operations between North Vancouver and Prince George. The study showed that the relative price of diesel fuel versus electrical energy would need to more than double to produce savings adequate to support the cost of capital, low as it was at that time.

Preliminary studies for access to the northeast coalfields touched on electrification in 1975/76. This was prompted by concern over ventilation when long tunnels were considered in route alternatives.

Electrification was not pursued, partly because of estimates of the cost of increased rock excavation required for electrical clearances, erroneously based on wire heights often used on the old Eastern U.S.A. systems in open country.

There existed no convincing modern electrification data of any kind that could be related to the type of heavy coal trains contemplated and B.C. Railway assembled adequate operating plans based on diesel locomotives to support northeast coal development studies.

At about the same time, the Salt River Project Navajo power plant put a private 78-mile electric coal hauling line into operation in Arizona, energized at 50 kV. Hitherto railways had not worked at over 25 kV.

Also, at that time, the U.S. Federal Railroad Administration (F.R.A.) commissioned a theoretical study of the potential for "dual mode" locomotives, i.e. a true hybrid locomotive with electrical capabilities equal to or better than its standard diesel power. The study contemplated piecemeal but progressive electrification along existing major routes starting wherever heavy traffic flows or heavy horsepower demands made electrification most financially attractive.

In Canada, a watching brief was sustained by certain members of the Railway Advisory Committee (R.A.C.), itself a link between the Railway Association of Canada and the Transportation Development Centre (T.D.C.) of Transport Canada. By membership in the Railway Association of Canada, B.C. Railway participated in the watching, but it was not until 1981 that the topic of electrification in Canada burst out from a half century of side talk.

In 1981, several events occurred. The F.R.A. dual mode study was published and discussed by some R.A.C. Members. Electrification was listed as a topic worthy of T.D.C. support. Peter Detmold, Chairman of R.A.C. publicized the use of electrification to overcome the speed limitations of diesels on heavy grades. B.C. Railway considered the

use of dual mode for tunnel working due to the high capital costs involved in the projected tunnel ventilation required for the diesel locomotives. B.C. Railway re-assessed the question of tunnel height for electrification.

B.C. Railway examined operating costs, capital savings, and possible assistance available from T.D.C. for electrification development and from Federal/Provincial Conservation and Renewable Energy programs.

Through T.D.C. support, utilizing a study that had been concluded in a proposed electrification program over a segment of a rail line in Eastern Canada, a feasibility review to electrify a portion of the Branch Line was carried out in early 1982. This study concluded that electrification would be feasible operating on a 50 KV system using modified Swedish technology.

On May 7, 1982, B.C. Railway directors were appraised of the favourable case for electrification, and permission was obtained to take a review panel of electrification experts over the entire branch line route.

With favourable indications from the review panel, funding agencies and locomotive suppliers, an immediate start was made to secure key components such as locomotives, power transformers, and manufacturing rights for Canada of the preferred Swedish hardware designs.

Formal ratification of all steps took several more months, but the process was smoothed by considerable enthusiasm for electrification at all levels and interim approval was always available for the immediate work in hand, recognizing the critical time schedule which was already a feature of the overall branch line project.

Economic analysis was very much site specific to the branch line. The key factor was eliminating the cost of ventilation fans and control gates needed for adequate air cooling of multiple diesel locomotives.

However, as soon as the premise of electrifying the tunnels was tested, it became apparent that the necessary electrical substation and power feed into the tunnels contained a fixed cost that could substantially support electrification of the entire branch line. Progressively, the concepts of tunnel electrification only, mixed diesel and electric locomotives, exclusive electric locomotives, and maximum extension of power supply to main line connection at Anzac, were found to improve the overall rate of return for added increments of investment. Improved returns came from the well known energy cost advantage of electrification on heavy fuel usage and the reduced maintenance costs of electric locomotives.

The availability of funding through the Federal/Provincial Conservation and Renewable Energy programs was also a significant factor.

CONCEPTUAL DESIGN

Outline

The passing of heavy trains through long tunnels presents a major problem with diesel traction. The tunnel has to be ventilated using fans of several hundred horsepower to cool the locomotives and provide fresh air for combustion and the operators. The capital cost and energy consumption of these fans and associated mechanical equipment, including automatically operated doors in the tunnel portals, is substantial, particularly in those cases where there is no existing high voltage transmission in the tunnel area and power has to be brought in by new transmission facilities. For the Tumbler Ridge Branch Line, the cost of ventilation including power supply facilities was estimated to be \$12 million.

Electrification Studies

In view of the high cost of the tunnel ventilation required with diesel locomotives and other potential advantages of electrification particularly diesel fuel displacement and increased capability in the event of further development of the coal fields, B.C.R. and the Canadian Transportation Development Centre (TDC) decided in February 1982 to commission a study of electrifying a part or all of the Tumbler Ridge Branch Line.

A number of options were screened in the initial phase of the study including an electric pusher operation with three diesel and two electric locomotives and electrification from km 25 to km 115 only, with diesel operation in the load-out loops of the mines. As a result of these screening studies, it was concluded that once a substantial portion of the new branch line is electrified, the potential benefits are of such magnitude that the electrification of the whole branch line from km 0 at Anzac to km 130 at Tumbler Ridge is the best option.

The basic criteria for the second phase of the feasibility study was the requirement that the electrified branch line could handle up to four 13,000 tonne unit trains per day at speeds contemplated for the diesel operation. In addition, two other important constraints were recognized.

Firstly, the system adopted had to be compatible with likely systems for mainline electrification in Canada which narrowed the alternatives to be considered to 25KV, 60 Hz or 50KV, 60 Hz catenary power.

Secondly, the severe limitations of existing high voltage power transmission feeds into the area had to be taken into account. The Provincial utility, B.C. Hydro has three 500 KV lines transmitting power from the Peace River hydro plants to the Central Interior and Lower Mainland districts passing near Anzac. The tapping of these high security lines with the required standard of reliability required by this type of major utility transmission was estimated to cost \$15 million. There is a 132 KV line going north not far from Anzac. This line, however, is already fully loaded and could not carry any substantial extra load required by the railway. The construction of another 132 KV line from the nearest 500/132 KV or 230/132 KV substation was also estimated to cost in the order of \$15 million. The electrification could not justify the additional cost of these special transmission facilities. The only available power supply into the area to feed the electrified railway, is a new 230KV transmission line constructed by B.C. Hydro between its Gordon Shrum Generating Station on the Peace River and Tumbler Ridge.

This is a single circuit line, 140 km long, dedicated to serve the Northeast Coal Block.

Once the decision was made to electrify the Tumbler Ridge Branch Line from Anzac through to the mine sites, the type of systems to be used were studied. It was concluded that the substation would be a 230/50 KV substation to be located at km 112 and the open country catenary would be based on the Swedish State Railway design.

A 50 kV system was selected for the project when it was decided to electrify the entire branch line and not just the tunnels and steep grades. The 50 kV system provides power over the full branch line using one substation. The Railway substation is directly adjacent to a B.C. Hydro and Power Authority substation that services the mine sites and townsite. A short 50 kV feeder line then transmits the electrical power to the overhead contact system above the track.

The substation has two 230/50 kV single phase transformers rated at 25/33 MVA. These transformers normally operate in parallel but each has the capacity to supply the full demand on their own in the event that one transformer is out of commission. The substation has a conventional protection system for the transformers, capacitor and filter banks. The protection and control system is remotely monitored and operated from the Power Bureau in the B.C. Rail head office in North Vancouver as are the catenary disconnects.

The Overhead Contact System (O.C.S.) is of the 'simple catenary' type using a copper contact wire and a stranded copper messenger wire. This construction is considered to be adequate for speeds up to 100 km/hr. A 50 kV feeder wire mounted on the catenary poles is paralleled with the contact system. The ground return circuit consists of the earth itself, the rails and a ground return conductor installed on the outside of the catenary poles. As there are no long cables, open wire signaling or communication circuits paralleling the Branch Line requiring reduction of electro-magnetic interference, the system does not employ booster transformers. Commissioning tests will, however, make precise measurement of electromagnetic fields to facilitate any future railway electrification within urban areas.

The O.C.S. is divided into sections over its entire length with remote/local controlled disconnects. This enables sections of the electrified system to be disconnected for maintenance work and still allow other sections, for example the load-out loops, to be operational.

ENERGY IMPACT

Energy Impact of Electrification

There are two principle benefits being derived from the operation of the Tumbler Ridge Branch Line using electricity. These are; first, the use of less energy to move the product from the mines to the B.C. Rail mainline and second, the conversion from the use of a non-renewable fossil-fuel to a renewable hydro-generated electricity. Additional benefits are also obtained from reduced locomotive maintenance and the elimination of the ventilation systems in the two major tunnels. The electrical system is also environmentally cleaner and quieter than diesel power. The only new area of maintenance is the catenary system that delivers energy to the locomotives.

The conversion to electrical energy is expected to give an annual saving of \$980,000 (\$1982) by 1986 when the mines are producing coal at their planned capacity of 8.5 million tonnes per annum.

The energy consumption figures shown herein are derived from a series of computer analyses based on the number of locomotives, train length and weight and track gradient. These figures are the projected energy usage and over the coming year. Field data will be collected and analysed to give actual energy consumption comparisons between diesel power and electrically powered locomotives.

Through the use of electrical energy, it is shown that the energy consumed will be reduced by 63% which makes electrical energy 2.7 times as efficient as diesel fuel. Over a ten year period, the electric locomotives will save in excess of 91 million litres of high grade diesel fuel in transporting 85 million tonnes of coal through the Rocky Mountains.

Owing to the fact that diesel locomotives are approximately 27% energy efficient and the electric locomotives are 85% energy efficient and there is a 10% energy loss in the electrical distribution system, it is calculated that in the diesel operation, the locomotives will consume 9,330 litres of fuel on each round trip. The electric locomotives will use 37,000 KW hours of electrical energy. This translates to 360 gigajoules of diesel energy and 133 gigajoules of electrical energy. To move the 8,918 tonne train there is a saving of 227 gJ of energy per trip. This saving of energy can be directly translated into dollar savings.

ESTIMATED ANNUAL FUEL CONSUMPTION

<u>YEAR</u>	<u>TRIPS</u>	<u>DIESEL FUEL (LITRES)</u>	<u>DIESEL FUEL (GJ)</u>	<u>ELEC- TRICITY (KW-HRS)</u>	<u>ELEC- TRICITY (GJ)</u>
1984	700	6,540,000	252,000	25,900,000	93,100
1985	881	8,230,000	317,160	32,597,000	117,175
1986 and on	953	8,903,000	343,080	35,261,000	126,750

The annual fuel savings are calculated to be \$289,000 in 1984, \$603,000 in 1985 and, when the mines are delivering coal at their contracted capacity from 1986 and on, \$729,000, as shown in the following table.

ESTIMATED ANNUAL DOLLAR SAVINGS
COMPARING DIESEL TO ELECTRICITY

<u>YEAR</u>	<u>NO. OF TRIPS</u>	<u>COST OF DIESEL FUEL \$1000</u>	<u>ELECTRIC COST</u>		<u>TOTAL ELEC. COST \$1000</u>	<u>DIESEL LESS ELEC. \$1000</u>
			<u>ENERGY CHARGE \$1000</u>	<u>DEMAND CHARGE \$1000</u>		
1984	700	1,793	581	923	1,504	289
1985	881	2,257	731	923	1,654	603
1986	953	2,443	791	923	1,714	729

1. All based on 1982 dollars.
2. unit prices of fuel and electricity are October 1982 rates.
3. electric costs based on standard power tariffs.

As can be seen, there are substantial savings in fuel cost alone from the use of electrically powered locomotives.

ECONOMIC ANALYSIS

The cost of laying 30 km of line and boring two tunnels was \$455 million. Electrification was only a fraction of this, at \$50 million.

Cost of Electrification

Power supply & connection charge	\$ 4.71 million
Catenary	\$19.83
230 kV powerline into Tumbler Ridge	\$ 4.90
Electric locomotives (seven)	\$19.90
Other	<u>\$ 0.66</u>
Total (Electric)	\$50.00 million

Cost of Diesel System

Diesel locomotives (seven)	\$14.8 million
Tunnel ventilation system	<u>\$24.0</u>
Total (Diesel)	\$38.8 million

Net Incremental Cost of

Electrification	<u><u>\$11.2 million</u></u>
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Annual Cost of Energy: (1982 \$, Fuel and Electricity)

<u>Year</u>	<u>No. of Trips</u>	<u>Diesel Fuel Energy (\$M)</u>	<u>Electrical Energy (\$M)</u>	<u>Savings Per Year (\$M)</u>
1984	700	1.793	1.504	0.289
1985	881	2.257	1.654	0.603
1986	953	2.443	1.714	0.729
and on				

There are savings to be gained in the reduced locomotive maintenance and maintenance on the tunnel ventilation system. Offsetting a part of these savings, is the cost of maintenance of the substation and catenary system.

Annual cost of locomotive maintenance

Diesel (7 engines)	\$1.05 million
Electric (7 engines)	<u>\$0.70 million</u>
Savings	\$0.35 million

Annual cost of catenary maintenance
with electrical system

\$0.30 million

Annual cost of tunnel ventilation
maintenance with diesel system

\$0.20 million

Annual savings of electrical system
over diesel system (1986)

\$0.979 million

Rate of Return and Payback Period

The discounted cash flow rate of return on the additional investment of \$11.2 million using the annual savings is 5% prior to any grants.

The payback period of this project (in constant dollars) is 13 years, without funding. With the \$5 million CREDA grant the payback period is reduced to 8 years.

DEMONSTRATION ASPECTS OF ELECTRIFICATION

The electrification of the Tumbler Ridge Branch Line is an opportunity to demonstrate the advantages of a 50 kV electrified railroad system that could be implemented on the national railroad system.

The 50 kV system requires fewer connections to the high-voltage power grid than the lower voltage systems used in Eastern Canada, the United States and Europe. With the high population densities of these areas which have closely spaced power grids, it is easier to install many more substations at more frequent intervals to feed a lower voltage catenary system.

These low-voltage systems are not suitable for use in the sparsely populated regions of Canada because the main transmission lines are rather far apart and a lengthy feeder transmission line system would have to be built to service the necessary substations.

The 50 kV system that is used on the Tumbler Ridge Branch Line requires 25 to 50% of the number of substations needed for a lower voltage catenary. This voltage system has only been used twice before in the world. These are for the 126 km Black Mesa to Lake Powell coal hauling railroad in Arizona and the 860 km Sishen to Saldanha Bay railroad in South Africa.

There is potential to use this same system wherever there is heavy tonnage, long grades and/or high speeds affecting train operation.

A 50 kV system could be used on the other railroads crossing the Rocky Mountains in Western Canada and in the Toronto to Montreal core in Eastern Canada

The information gained from this project is being made available to other Canadian railroads through the Railway Advisory Committee of the Railway Association of Canada. This Association meets regularly to discuss current technological advances in railroad technology.

Through the B.C. Rail Corporate Information Service, the construction of the Tumbler Ridge Branch Line is documented on slide and movie film.

CONCLUDING COMMENTS

The energy consumption of the Tumbler Ridge Branch Line is expected to be reduced by 63% by conversion from diesel fuel to hydro-generated electricity. The funding available from by the Conservation and Renewable Energy Demonstration Program gave an added incentive to conceive, design and install the 50 KV electrification system on B.C. Railway's Tumbler Ridge Branch Line.

The overall performance of the system is being evaluated over the next year. The locomotive efficiency is being tested using a test car provided by General Motors of Canada. This information, along with the energy consumption information that will be collected, will yield a verified correlation between diesel fuel and hydro-generated electricity for rail transportation. The data and analysis of the energy consumption will be submitted as a supplementary report.

APPENDIX A

LIST OF REFERENCES

Planning and Construction of the Tumbler Ridge Branch Line
V.W. Shtenko et al
CTM Bulletin May 1983

Tumbler Ridge Branch Line Electrification Proposal
B.C. Railway October 1982

APPENDIX B

PROJECT COSTS
(Excluding Locomotives)

	<u>Total Cost</u> <u>to Mar. 2/84</u>	<u>Projected</u> <u>Cost to</u> <u>Completion</u>	<u>Total Cost</u>
Total Project Costs	\$26,605,875	3,494,125	30,100,000
Less Other Grants Received	<u>\$ 2,905,000</u>	<u>1,295,000</u>	<u>4,200,000</u>
Actual Eligible Cost for CREDA Grant	\$23,700,875	2,199,125	25,900,000